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POPULAR TREATISE

ON

VOLTAIC ELECTRICITY

AND

ELECTRO-MAGNETISM;

ILLUSTRATED BY NUMEROUS INTERESTING EXPERIMENTS,

WITH THE MODE OF PERFORMING THE SAME.

BY G. eorge H. enry BACHHOFFNER.

Author of "Chemistry, as applied to the Fine Arts," "The Medico-Chemical Compendium," &c., &c.

And Lecturer on Chemistry to the Artists' Society.

Price 1s. 6d. with Plate of Apparatus.

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PREFACE.

THE Author of the following pages, in presenting them to the Public, begs leave distinctly to state, that his chief object has been to arrange for the guidance of those unacquainted with the subject, a series of interesting experiments; together with such practical information as the limits of the work would permit.

He therefore wishes it to be understood, that he does not aim at any originality in the subject matter of the work, but that it is merely intended as a Popular Treatise—designed chiefly for the use of amateurs.

A POPULAR TREATISE ON VOLTAIC ELECTRICITY, ETC.

GALVANISM, OR VOLTAIC ELECTRICITY.

THE term Galvanism, is derived from the name of a philosopher of Bologna, who, in the year 1790, accidently discovered that violent contractions may be produced in the muscles of a recently killed frog when touched by two opposite metals, such as silver and zinc. This circumstance, together with the controversy which afterwards ensued between Galvani, of Bologna, and Volta, of Pavia, laid the foundation of one of the most important sciences, which, in the short space of a few years, has effected such changes in some of the more important branches of Natural Philosophy, as can be equalled only by the brilliant discoveries of Sir Isaac Newton.

EXP. 1.—Divide the hind legs of a recently killed frog from the body, by cutting through the vertebræ, or back bone, in such a manner that the nerves may remain attached to the former; then carefully detach the skin from them: if we now place the nerves on a piece of silver, as a half crown, and the feet on a piece of zinc, and connect the two metals by a bent wire, the convulsions observed by Galvani, will immediately be produced as often as the connexion is made, or until the nervous influence ceases, and the muscles becomes rigid.

To account for this extraordinary fact, Galvani conceived the convulsions to be produced by a disturbance of the Electricity inherent in animals; which was then considered (as it is by many physiologists of the present day,) to be identical with the nervous fluid; and, that the metals employed acted only as conductors for the transmission of the Electricity from the nerves and the muscles, by which the convulsions were produced.

The origin of the term Voltaic Electricity, is derived from the name of Professor Volta, who, soon after the preceding discovery, satisfactorily refuted the erroneous view entertained by Galvani, of the source of the Electric action. This led to the controversy before alluded to. Volta endeavoured to prove that the muscular contraction resulted from the Electricity given out by the contact of the metals, the nerves and muscles acting merely as conductors of the electric fluid.

To prove that Electricity was developed by the mere contact of two opposite metals, he insulated two metallic plates after the method first pointed out by Mr. Bennet, one of zinc, and another of silver: these, when brought into contact and afterwards separated, were found to be electrified; the zinc positively—the silver negatively. Reasoning upon this important fact, he was led to the construction of the Voltaic pile.

Exp. 2.—The latter instrument may be easily arranged in the following manner: provide an equal number of either square or round pieces of sheet zinc, and thin sheet copper, and half the number of pieces of card-board or flannel; either of the latter to be well soaked in diluted acid,* previous to being employed. If any considerable number of plates are about to be made use of, it will be necessary to provide a board, having three upright pieces to support the series, which must then be arranged in the following order:—A plate of zinc being first laid down, it is to be covered by one of copper, and the latter by one of the pieces of moistened flannel: the same order to be observed throughout—viz., zinc, copper, flannel—until the whole are disposed of; taking care that, in no instance, is the order reversed: we shall then have the top of the pile terminating in copper, and the lower end in zinc;* to each of which may be attached a wire, forming what are termed the poles. If the pile be of sufficient extent, say forty pairs, and the hands, being moistened with water, are applied to the latter, a shock will be felt each time the contact is made. *See fig.* 1.

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* A mixture of one part of sulphuric acid to forty of water.

In Volta's hypothesis (which has received the name of the Electrical theory), the Electricity of the pile is considered to be the result of the contact of the metals; and that the interposed pieces of moistened flannel act simply as imperfect conductors for the transmission of the fluid from one pair of plates to the other.

This theory (by many considered inaccurate) has been modified by Sir H. Davy, and called by him the electro-chemical theory of Galvanism. Before entering into the examination of which it will be necessary first to consider that of Dr. Wollaston, called the chemical theory.

In this the Electricity of the pile, as also that of the electrical machine, is supposed to be derived from chemical action, in the oxidizement of the metals employed. This theory premises that no chemical action takes places without a transfer of Electricity; or, in other words, a disturbance of the electric equilibrium of the bodies acted upon. In the simple Galvanic circle, the zinc is chemically acted upon, the water supplying the oxygen to the zinc, forming oxide of that metal; the latter being dissolved by the free acid in the solution. In this case, the zinc acquires a negative electrical state as regards the solution, which is in the opposite or positive state.

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* In all compound batteries, the first and last plate are generally considered to act only as conductors, not being concerned in the action.

Sir H. Davy, in his theory, endeavours to combine the two preceding, viz., the electrical theory of Volta, and the chemical theory of Dr. Wollaston. In this it is presumed that, in addition to the disturbance of the electric equilibrium by contact, as laid down by Volta, Wollaston's theory is added, inasmuch that the chemical changes contribute to the general results: and further, that all bodies, whether in combination or not, possess inherently different states of electric power or energy, some being naturally negative, as oxygen, chlorine, iodine, and the acids; others, on the contrary, being naturally positive, as hydrogen, sulphur, and the metals that the union of bodies chemically may be referred to these opposite states; and that as some of them are very dissimilar, so are the elements of the compound more closely united. To account for the decomposition of these compounds by the Galvanic fluid, it is presumed that the power holding the elements in union, is subverted by the superior power of the latter; in which case, the electro-negative bodies appear at the positive pole of the battery, and the electro-positive at the opposite or negative pole; or, in other words, that chemical attraction may, in fact, be effected by the agency of Electricity.

We are however indebted to Mr. Faraday for some of the most important facts connected with the subject of electro-chemical decompositions.

It is a subject of deep regret to every lover of the science, that the important papers of this Gentleman, (denominated researches), published from time to time in the philosophical transactions, have not been collected and published as a separate volume.

It being contrary to the design of this work to enter into any lengthened examination of these theories, we shall not incline either to the Electrical or chemical theories of Galvanism; our object being chiefly the arrangement of those experiments constituting some of the most interesting features of the science, and not to bewilder the reader by leading him through the maze of speculative theory.

Apparatus for exhibiting Galvanic Electricity.

The most simple construction for this purpose is that of a single pair of plates, as zinc and copper; forming the simple Galvanic circle. These may be immersed in any convenient vessel, as a glass tumbler or jelly-pot, holding the dilute acid. *See fig.* 2. A current of Electricity is immediately established, passing from the zinc through the liquid to the copper, and returning again to the former in the direction pointed out by the arrows. Precisely the same effects will result if, instead of causing the metallic plates to touch at *a*, the current is allowed to proceed through the wires, as in *fig.* 3. In this case, the passage of the current is seen by the direction of the arrows, viz., from the zinc to the copper, through the liquid, returning again to the zinc, through the conducting wires or poles. By the addition of the latter, we are enabled to direct the electric current in which ever direction we may require: by this means also facility is given to the interruption of the current at any required moment, by separating the poles.

Thus, supposing we are desirous of causing the current to pass through the muscles of the frog, as in Exp. 1. then, if the pole *a*, be connected with the nerves, and the opposite one, *b*, with the feet, very violent convulsions will be produced at every successive contact.

Experiments with a single pair of plates.

Exp. 3.—Immerse a plate of zinc and copper in a tumbler, containing dilute sulphuric acid, taking care that the metals do not touch each other;

while in this state it will be found that gas is evolved from the zinc plate only; if while this is going on, the copper be made to touch the zinc, the gas will be given out more copiously, and from the copper surface also.

Exp. 4.—This experiment has been very interestingly varied by Mr. Sturgeon, in the following manner:—Pour into a tall air jar dilute acid, have ready a piece of amalgamated zinc* small enough to lie at the bottom of the jar; provide also a spiral of copper wire, place the zinc at the bottom of the vessel previous to pouring in the acid; no gas will be seen to rise from the latter if well amalgamated: if the spiral of copper wire be now made to touch the zinc through the acid and water, the whole of the convolutions of the wire will evolve gas, in a very interesting manner.

To obtain the Galvanic flash of light.

Exp. 5.—Place a small piece of zinc between the teeth, and in contact with the tongue; place also the curved handle of a silver spoon in connexion with the eye-ball, bring the bowl of the spoon in contact with the zinc between the teeth: every time the contact is made, a strong metallic taste will be perceived, and a flash of light will appear to dart through the eye-ball, but without any inconvenience.

Exp. 6.—If a piece of silver is permitted to remain, however long, in a solution of sulphate of copper, no action will take place, but if on the contrary a piece of zinc be placed in the liquid, it will be immediately coated with a film of metallic copper. If we now bring the upper ends of the zinc and silver in contact, the Galvanic circle will be completed, and the copper will be precipated on both the metals.

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* Zinc is readily amalgamated by pouring dilute acid into any flat vessel, with a few globules of mercury, by rubbing the surface of the zinc in contact with the latter under the acid, the mercury combines very readily with the zinc.

Exp. 7.—Mr. Sturgeon has shewn that a Galvanic circle may be established by only one sort of metal, when the particles on their respective surfaces, are in different degrees of compactness. In this manner he states, a very energetic Voltaic combination may be formed by employing a plate of rolled zinc and one of cast zinc, in which arrangement the smooth surface takes the character of zinc, as in the standard battery, and the roughened piece that of the copper.*

Exp. 8.—The following beautiful experiment was originally suggested by Dr. Wollaston, and explains the action of the sustaining battery, to be mentioned hereafter, in a very satisfactory manner. Take a piece of glass tubing, open at both ends, and of about an inch internal diameter; tie securely over one of the ends a diaphragm of bladder; fill the tube with a solution of the acetate of lead; a cork must then be fitted to the open end, through which insert a piece of bright copper wire of sufficient length to nearly touch the bladder in the inside, and so as to communicate with a piece of zinc placed underneath, and in contact with the bladder on the outside; this is conveniently managed by placing the tube perpendicularly on a flat piece of zinc; in a few minutes a beautiful precipitation of metallic lead will be observed at the extreme end of the copper wire, gradually increasing in size.

A compound Galvanic circle is simply two or more of these connected together as shewn in *fig.* 7, where the zinc of one pair is in connexion with the copper of the following, and so on throughout the series, zinc—fluid—copper—the current travelling as before, in the direction pointed out by the arrows: the zinc end of the battery being generally regarded as positive, and the copper negative.

Various have been the improvements suggested by different experimentalists in the construction of the

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* Recent experimental researches in electro-magnetism and Galvanism.

Voltaic battery; of these our limited space will only permit us briefly to notice the most important.

Previously to Volta's making known his invention of the pile, he constructed, it appears, an arrangement, to which he gave the name of *Couronne de tasses*, represented in *fig.* 11, consisting of any number of tumblers or small jars, half filled with acid, or salt and water, containing a series of metallic arcs, formed of a plate of zinc and copper connected together by a metallic wire; arranged as seen in the figure. This simple battery, notwithstanding all our improvements, is very convenient, from the facility with which it may be constructed.

The next improvement was that of Mr. Cruikshank in whose arrangement a plate of zinc and copper were first soldered together at the edges, and afterwards cemented in a wooden trough, at the distance of half an inch from each other, the vacant spaces between each pair of plates being filled with dilute acid and water. *See fig.* 4. The latter arrangement has been variously modified by substituting porcelain for the wooden troughs, and by making the plates moveable, so that they may be immersed at any required moment; a point of considerable importance in acid batteries,—the first few moments of immersion being in all cases the most energetic.

The next important improvement was that suggested by the late Dr. Wollaston, in which the copper plate is made to surround the zinc as shown in the *fig.*5.

By this plan it is considered that both surfaces of the zinc are brought into action.

These several arrangements are now in a great measure superseded by the recent improvement of Professor Daniell, of King's College, in the construction of the apparatus, to which he has given the name of sustaining battery.

In the previous forms of the Voltaic battery, dilute acids were employed as the exciting agents; the strength of which gradually diminished with the length of time the battery was kept in action, together with several other inconveniences, such as, the formation of oxide on the surface of the zinc plate; thereby impeding the direct action of the remaining acid, together with the escape of hydrogen gas, resulting from the decomposition of the water, and the precipitation of metallic zinc on the copper-plates.

These several impediments acting in opposition to the development of the full effects of the battery, tended much to diminish the utility of the apparatus as an instrument of research. Little dependance could be placed on its action after being immersed in the acid for a very short time; and when an extensive series were required, it amounted to a very serious inconvenience, as the plates first immersed were sinking gradually in action, before the last set of plates could be excited.

Mr. Warren de la Rue has endeavoured to remedy these defects by employing a saturated solution of the sulphate of copper, slightly acidulated with nitric acid; by which means the action is kept up for several hours.

This gentleman considers that the evolution of hydrogen gas (resulting from the decomposition of the water,) carries with it a considerable portion of the Electricity developed by the battery; and that also the heat evolved by the chemical action, produces an evaporation of the fluid contents of the battery: the vapour formed carrying with it (as in the case of hydrogen) a portion of Electricity.

These several objections are almost, if not entirely, obviated by the invention of Professor Daniell.

It appears he was led to the construction of this arrangement from his observations of the two following points. 1st. As regards the action of the evolved hydrogen. 2nd. That of the relative surface of the zinc and copper forming the plates of the battery; the action of the nascent hydrogen he found to consist in its tendency to deoxidize the oxide of zinc, formed during the chemical action of the acid upon the latter; the revived metal being deposited upon the negative plate or copper surface of the battery.

The continued deposition of zinc on the copper surface diminished successively the action of the battery, in proportion as the copper became coated; it therefore became necessary to obviate the injurious tendency resulting from this action: this was in some measure effected by adding nitric acid to the usual charge of the battery; its action being to dissolve the metallic zinc, precipitated upon the copper: this however it appears was not sufficient, and he found that if the hydrogen was removed by causing it to deoxidize a metallic solution, the metal precipitated from which should not interfere with the action of the negative surface, that great increase of power was obtained, together with a steady and continued action. 3rd. As to the importance of an increase of size in the copper surface over that of the zinc, the latter he found might be successively reduced to a mere rod of that metal, without any diminution in the effect. The result of these observations led to the construction of his sustaining battery.

It consists of a cylindrical vessel of copper, having a membrane (as the gullet of an ox, passing through the centre), the latter terminating in a glass syphon without the cylinder; in the inside of which is suspended a rod of zinc: in order to excite this battery, dilute acid is poured into the membrane, and outside of the latter a solution of sulphate of copper.

Of the relative merits of this arrangement over the old form of battery, we are unable experimentally to speak; but the published accounts of its power as given by the inventor in a letter to Dr. Faraday, clearly point out its superiority over those before mentioned.

The battery we have now to describe is one recommended by the author, being a modification of that first proposed by the above Professor. It is not presumed that it possesses any superior qualities over that of Professor Daniell, (to whom unquestionably belongs the merit of having first introduced this arrangement), except that of simplicity of construction, and consequent decrease in the original cost.

The battery is represented in *fig.* 6. it consists simply of a scroll of thin sheet copper, (open at both ends,) fastened together without solder, by which means all local action is prevented. A sheet of stout zinc of the same size is then coiled up in a similar manner, each scroll being furnished with a copper wire to act as poles; a thin bladder is tied loosely round the copper, leaving it open at the top, and the construction of the battery is completed: to excite it, place it in any convenient vessel, as a small jelly pot; put inside the copper cylinder, a saturated solution of sulphate of copper, which is of course retained in its position by the surrounding membrane, and outside the latter, and in contact with the zinc, a solution of common salt in water; the two extreme ends of the poles or conducting wires being dipped into a solution of the nitrate of mercury, in order to amalgamate them;* the battery is then ready for action and will retain its activity for two or three days.

Fig. 7. represents six of these batteries in a box: here, the conducting wires connecting each pair of plates have been removed, and binding screws substituted, the heads of the latter being hollowed out so as to form mercury cups, if requisite; these are intended to obviate the inconvenience frequently resulting from the wires being attached to the plates. In this arrangement it is only necessary to place the ends of the wires in the screw holes, the latter serving to fix them at the required distances.

The battery of six jars *fig.* 7 is quite sufficient for exhibiting, on a small scale, all the most interesting experiments connected with the science as given in the following series.

To exhibit the combustion of charcoal points.

EXP. 9.—The charcoal for this purpose should be made of box wood or ebony, in the following manner; shape the pieces as nearly as possible into the form of a pencil, place them in a crucible and well cover them with sand; the crucible and its contents must then be exposed to the action of a strong fire for two or three hours; when nearly cold the pieces should be removed and preserved in a closely stopped phial. Take two of these pieces of charcoal, and scrape them to a very fine point, fasten each piece with a fine wire to either pole of the battery; if these are now brought carefully together, the brilliant Galvanic light will be evolved, accompanied by the combustion of the charcoal: this may be repeated as long as the battery remains in action.

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* This is essentially necessary in all Voltaic and Electro-Magnetic Experiments.

Exp. 10.—To exhibit the combustion of steel wire, procure a reel of watch pendulum wire: if one of the pieces of charcoal be removed, and two or three inches of this wire substituted in its stead, the wire on being made to touch the charcoal, in connexion with the other pole of the battery, will undergo combustion, throwing out very beautiful scintilations.

The ignition of platina wire.

Exp. 11.—Remove the steel wire and charcoal from the poles of the battery; place one of the poles in either of the mercury cups of the apparatus. *See fig.* 22. The piece of platina wire, *a*, *b*, will remain at a bright red heat so long as the connexion is maintained.

To exhibit the combustion of the metals.

Exp. 12.—Pour into a watch glass a sufficient quantity of mercury to cover the bottom, into which place one of the poles of the battery: to the other attach a small piece of gold, silver, or copper, leaf: if either of these be now brought into contact with the mercury in the watch glass, the metallic leaf will undergo vivid combustion, displaying different colours, according to the metal employed.

To shew the decomposition of water.

Exp. 13.—Place the poles of the battery in the mercury cups of the decomposition apparatus, *fig.* 8, which must previously be filled with water acidulated with sulphuric acid; as soon as the connexion is made, the water will rapidly undergo decomposition, being resolved into oxygen and hydrogen gases. If, when all the water is ejected from the tube, the mouth of it be presented to the flame of a candle, a slight explosion will take place, resulting from the explosive character of the mixed gases.

An interesting variation of this experiment is effected by employing two tubes instead of one, in which case the gases are evolved separately; the tube connected with the negative or copper end of the battery containing the hydrogen, and the other the oxygen. The quantity of gas in the former, compared to the latter, when the experiment is correctly performed, is in the proportion of two to one.

The Voltameter, *fig.* 9, is an instrument for measuring the relative amount of gas evolved during a given time, from any Voltaic arrangement under examination; the quantity of gas being supposed to indicate the amount of Electricity which is circulating through the battery: thus, the small compound battery of six jars will evolve a cubic inch of gas in two minutes.

Now, supposing we are anxious to ascertain the relative powers of any two Voltaic batteries exposing the same extent of surface? It is evident, if the above instrument be a correct indicator, that that battery which evolves the most gas in a given time has the greatest amount of Electricity circulating through the series. (We, of course, allude here to the action of the compound or intensity batteries.)

To use the Voltameter, draw the tube about two inches from the bottom of the vessel, or a sufficient distance to admit of the acidulated water in the interior of the glass covering the mouth of the tube, when inverted. Place the finger over the hole *c*, and invert it; the air which previously occupied the tube, will be displaced by the superior weight of the water: gently press down the tube, and re-invert the vessel into its stand, so that the two platinum poles dip into the basons of mercury connected with the cups, *a, b,* place the ends of the poles into the latter, and the decomposition will immediately commence—the evolved gases passing into the tube.

To exhibit the decomposition of the neutral salts.

Exp. 14.—Fill the bent tube, *fig.* 12, with the blue infusion of litmus, and drop into the tube two or three crystals of any neutral salt, as the sulphate of soda, &c. Insert the corks and platina plates in their places and connect the poles of the battery with the wires, *a, a,*; in a short time it will be found that the blue colour in the tube, connected with the positive pole of the battery, will be changed to a red; and in the opposite or negative to a green, indicating thereby that the salt has undergone decomposition; the alkali or soda being in the negative tube, and the sulphuric acid in the positive tube.

Exp. 15.—The preceding experiment may be varied in the following manner:—Place three watch glasses parallel with each other, and connected together by moistened asbestos, or filaments of cotton; in the two outer glasses put a solution of litmus, and in the centre one a few crystals of sulphate of soda and water: connect the former with the poles of the battery. In a short time the salt in the centre will have undergone decomposition: the sulphuric acid will collect in the cup, connected with the positive end, changing the blue to red, while the alkali will pass into the negative cup, changing the blue infusion to a green.

To exhibit the production and combustion of the metals—Potassium and Sodium.

Exp. 16.—Connect one of the poles of the battery with a piece of platina foil, about a quarter of an inch square, on which place a piece of the hydrate of potass or soda about the size of a mustard-seed; the other pole must likewise terminate in platina.

Breathe gently on the potass, and then bring the opposite pole in contact with it; the potass will undergo decomposition, and the metal potassium will be produced, rapidly undergoing combustion at the moment of its formation.

Exp. 17.—To exhibit the decomposition of muriatic acid: Fill the bent tube, *fig.* 12, with water tinged blue by sulphate of indigo; into which a few drops of muriatic acid have been previously added, and proceed as directed in Exp. 14. In a short time, chlorine will be evolved; the bleaching properties of which will entirely destroy the blue colour of the indigo in one of the tubes.

To exhibit the decomposition of the Iodide of Potassium.

Exp. 18.—For this experiment a solution of starch must be prepared as follows: Pour on a tea-spoonful of arrow root three or four ounces of warm water of the temperature of 160°., and let it stand until cold; with this solution fill the bent tube, *fig.* 12, and drop into the tube two or three crystals of the iodide of potassium; connect the poles of the battery with the apparatus; in a few minutes the salt will be decomposed, the liberated iodine (acting upon the starch held in solution by the water,) combines with it, forming a blue compound of great beauty.

The physiological effects of a battery of this size are very feeble, it being necessary to have an extensive series, of several hundred pairs of plates, before a shock of any very great power can be communicated; by the aid however of another piece of apparatus (which we shall have occasion to describe under the head of *electro-magnetism*), shocks, exceeding in power the most extensive arrangement yet constructed, may be communicated by a single pair of plates.

Electro-Magnetism.

Electro-Magnetism at the present time engrosses perhaps a greater share of the attention of scientific men than any other branch of the combined sciences, termed Natural Philosophy; and it is by no means a subject of surprise that such should be the case, when we consider the novel and interesting character of its varied action on the one hand, and its intimate connexion with that class of bodies, commonly called imponderable, on the other. Philosophers had long considered some close analogy to exist between the electric and magnetic fluids: thus, a stroke of lightning has been known to destroy the magnetic polarity of the needle in the mariner's compass. Again, in other instances, to invert the polarity, such as making what is commonly called the North Pole of the needle a South Pole, and *vice versa;* and also that of rendering iron magnetic, which was previously unpolarized. Very great pains were taken by many experimentalists, to trace, if possible, their connexion, but with very little success, until the important experiments of M. Oersted, in 1819, were made public, although experiments and facts have been multiplied to an almost unlimited extent since then; still many consider that we are as far from the exact point which would enable us to define their identity (if they are identical), as we are still ignorant of the nature of the electric fluid.

Previous to the discoveries of M. Oersted's being made known, the two following experiments, offered perhaps the most conclusive evidence of the close analogy existing between the two fluids.*

Exp .1.—*To magnetize a needle by the electric discharge:* Place a sewing needle in the helix *fig.* 20, and send the charge of a Leyden jar through the convolutions of the wire, the needle will now be found to possess magnetic polarity.

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* We have employed the terms fluids, in common with other works; but no evidence has yet been produced to establish the point.

Exp. 2.—The same experiment may be repeated with the Voltaic battery, by bringing the poles of the latter in connexion with the two ends of the wire of the helix, mere contact, (even for a moment) is sufficient, in the latter case, if the plates employed possess sufficient extent of surface. The experiments of M. Oersted were all performed with the latter apparatus. The small sustaining battery *fig.* 6, with its conducting wires will answer the purpose.

Prior to entering into the examination of the interesting experiments that have at various times been made public, it is necessary that we should endeavour to state briefly the theories that have been adduced in illustration of the phenomena.

That proposed by the discoverer, M. Oersted, (although very generally adopted at the time of its promulgation) has given way for others apparently more conformable to the true nature of the action.

M. Oersted, with many other of the continental philosophers, still adopt the hypothesis of Du Fay, viz. (of two electric fluids), in the Galvanic battery, he considered that a separation of these fluids took place; these were carried along the conducting wires or poles, where they again (if the circuit was completed) entered into union; that this union was attended with a series of electric shocks, and to which he gave the term electric conflict, he further considered that the conflict acts only on the magnetic particles of matter, consequently all non-magnetic bodies (or those to which magnetic properties cannot be communicated) admit this electric conflict to pass through them, while on the other hand, the magnetic particles of ferruginous bodies are opposed to this action, or in other words resist the conflict; to account for the motion communicated to the magnetic needle (to be described hereafter) he imagined the conflict to move in circles.

The next is that of M. Ampére; in which theory, magnetism, or those properties which magnetised bodies usually assume, are attributed entirely to the action of electrical currents moving at right angles to the magnetic meridian; from this it is evident that magnetism is merely the result of electric action, and has no existence as a distinct principle, or matter; in this situation therefore we must (according to this theory) attribute the magnetic polarity of the earth, the peculiar character of which, is supposed by M. Ampére to be owing to the attractions of electrical currents revolving about the earth in circles, nearly parallel with the equator. Magnetism being defined to be simply the action of electrical currents revolving about every particle of such body in planes perpendicular to the axis; the magnetic attractions and repulsions, being merely the attraction, &c., of these electric currents.

The next and last theory we shall notice is, that of Mr. Sturgeon. If I understand him correctly, he considers that the magnetic fluid is not (as in the preceding) the result of electrical currents, but exists as a distinct principle, or matter, totally independent of any electric action whatever, in all metallic bodies, (and probably in every other sort of matter,) in some, as in the permanent magnet in a free state, in others, as in soft iron in a latent, or quiescent state.

The magnetic influence of a permanent magnet, he considers may be represented as a series of polar magnetic lines, extending outwards, in a rectilinear direction from the poles of the magnet. During the passage of the current through an electrified wire, it brings into action the hitherto latent magnetism of the wire, which, as in the case of the permanent magnet, arranges itself in the polar magnetic lines before alluded to, these having the same properties and modes of action as displayed by the terrestrial magnetism of the earth, or those exhibited by a permanent magnet.

Having thus briefly called attention to the principal theories which have been adduced in illustration of these interesting phenomena, we shall proceed with the experiments which constitute the leading principles of the science.

Exp. 3.—Screw into the two plates of one of the small batteries, *fig.* 11, a wire of about 2-feet in length, bend it so that one portion of the wire may be under the other, about the distance of an inch between, a current of Electricity will then circulate through the wires, viz., from the copper to the zinc, arrange the wire and the battery, so that the former shall be in the direction of the magnetic meridian; if we now place the magnetic needle, *fig.* 12, holding it by its stand between the wires, it will be thrown out of its due direction* (viz. North and South) standing nearly East and West—if the wire terminating in the copper-plate be uppermost, then the North Pole will be turned towards the West, if, on the contrary, the zinc wire, it will be towards the East, depending upon the direction of the current.

Exp. 4.—This experiment is better shewn by employing the apparatus, *fig.* 12; permit the magnetic needle to become stationary, then turn the apparatus so that the mercury cups shall be in the same direction as the needle, in this case the battery must have separate wires screwed into the respective plates, if the wire proceding from the copper-plate be connected with the cup nearest the North Pole of the magnet, and the other with the zinc, the needle will be deflected as before, the North Pole, in this case, being directed towards the East, the reverse will of course take place, if, as before, we reverse the poles.

The preceding experiment will enable us to understand the action of the Galvanometer. In this instrument, instead of having only the action of one wire, we have here the united action of several convolutions, hence it has been frequently termed the Galvanic multiplier. The instrument is usually employed to point out the comparative intensities of electric currents flowing through the wire, it being generally supposed that the amount of deflection bears a correct ratio to the quantity of Electricity circulating through the coil. The instrument is certainly of importance, when the object is to measure the amount of a feeble current of Electricity; but I think it by no means a correct indicator of large amounts, or where powerful currents are the subject of investigation.

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* Called the deflection of the needle.

The instrument, *fig.* 21, is very delicately arranged. It consists of two magnetic needles, with their poles in opposite directions, by which means, if the needles have both the same magnetic force, they overcome, by neutralizing each other, the influence of the earth's magnetism; and are consequently more readliy acted upon; for if one needle only be employed, it is evident that a portion of the influence of the electric current is expended in overcoming the tendency which the needle has to remain in the magnetic meridian, by the attractive property of the earth's magnetism. Instead also of its being on a pivot, they are suspended by a single thread of silk: we have here one of the needles below, and the other above, the wire; the delicacy of this instrument is such, that a small bar of bismuth furnished with two copper wires, upon being held between the thumb and finger at one of the ends, the wires at the same time being placed in the mercury cups, will give a permanent deflection of from 40°. to 50°.

The difficulty of retaining in the memory the relative actions of a magnetized needle when acted upon by an electrified wire, has suggested to several authors certain rules for at once determining the direction in which the needle should move, when acted upon by currents flowing in opposite directions.

We must remember that all electric currents move in one direction, as regards the conducting wires, when speaking of a single pair of plates, viz.—from the copper to the zinc, *See fig.* 3, supposing our face to be turned towards the North Pole of the earth (or rather that point to which the North Pole of a magnetic needle is attracted) then we shall have the copper at our head and the zinc at our feet; consequently, the current would be moving from our face downwards: if, however, we reverse the position of the two plates, it is evident that the direction of the current would be then from our feet upwards; under each position the needle would be deflected in opposite directions. Thus, when the current is moving from our face downwards, and a wire carrying the battery current, is placed above the needle, the North Pole is deflected towards our right-hand; if placed below it, the North Pole is then turned in the opposite direction: if we change the direction of the current, by reversing the position of the plates of the battery, so also will the deflections be the opposite of those given above.

The following formula of Ampére is perhaps the most simple for retaining their changes in the memory. If we conceive ourselves lying in the direction of the current, the stream of positive Electricity flowing through our head towards our feet, with the magnet before us, the North Pole of that magnet will be directed towards our right hand; if however, any of these conditions be reversed, the result is reversed likewise.

Exp.5.—*Fig.* 13, is the vibrating wire of Mr. Marsh. Place a small quantity of mercury in the trough immediately under the wire sufficient to touch the latter, place also the poles of a small horse-shoe magnet, so that the latter may be on either side of the mercury, connect one of the poles of the battery with the cup, and the other with the trough, a current of Electricity will be sent either up or down the wire, according to the position of the plates: the wire will be, in consequence of the electro-magnetic action, thrown out from the mercury, by which means the connexion with the battery is broken, the wire by its own weight, will take its former position, by which action, connexion with the battery is again made, the wire being thrown out as before. These alternations continue as long as the connexion with the battery is maintained, causing the wire to vibrate rapidly in one direction; if the poles of the magnet, or the poles of the battery, be reversed, the wire will then vibrate in the opposite direction.

Exp. 6.—*Fig.* 23. This apparatus is intended to exhibit the rotation of electrified wires round the poles of a permanent horse-shoe magnet, the Voltaic current being established in the metallic buckets *f*,*f*, these consist of double cylindrical copper vessels, and a single cylinder of zinc, furnished with bent wires, as seen in the *fig.* On dilute acid being poured into the copper vessels, a Voltaic current is immediately set up, passing in the usual manner from the zinc through the liquid to the copper, returning again to the former: as soon as this is effected, the four cylinders will commence revolving upon their axis, the copper cylinders in opposite and contrary directions, and the zinc cylinders in opposite directions to these.

Mr. Sturgeon has modified this experiment in the following interesting manner: instead of the two copper vessels, he has substituted two cylinders of cast zinc, the previous zinc cylinders being constructed of rolled zinc: on dilute acid being poured into the cast zinc cylinders, rotation is immediately established, proving that rotations may be obtained from one description of metal.

Exp. 7.—*Fig.* 17, is for exhibiting the directive property of a freely suspended electrified wire; its construction is simply that of a fine copper wire, formed into the shape of a spiral, attached to a disc of card, this when arranged, as shewn in the *fig.* and a current of Electricity is transmitted through it, (by connecting the poles with the mercury cups of the apparatus) the wire will have a tendency to arrange itself in a plane perpendicular to the magnetic meridian, and at the ame time exhibits the attractive and repulsive pro-erty of the magnet.

Exp. 8.—*Fig.* 18. This apparatus was invented by M. de la Rive, and is commonly called the floating battery: it consists of a plate of zinc and copper attached to a cork, in order that it may float on water, the plates being connected by a long conducting wire, folded into the form of a ring, the battery when placed in a basin of acidulated water, possesses, as in the previous experiment, the attractive and repulsive properties of the magnet, arranging itself in the magnetic meridian,—*fig.* 19, is a modification of the same apparatus.

Exp. 9.—Coil round a bar of soft iron a few yards of covered copper wire, place the latter on the table, and connect the two ends of the coil with the poles of the battery; on presenting a magnetized needle to one of the ends of the bar, either the North or South Pole (according to the coiling of the wire and the direction of the current), it will be forcibly attracted, the opposite pole being as powerfully repelled; the iron bar being converted, by the action of the electric current traversing the helix, into a powerful temporary, or electro-magnet, which ceases the moment the connexion with the battery is destroyed:* if, while the current is flowing through the wire, a sheet of paper, or card-board, be placed over the iron bar and coil, and iron filings are gently sifted over it, the latter will arrange themselves in the polar magnetic lines of Mr. Sturgeon, forming a very interesting experiment.

Exp. 10.—*Fig.* 10, is an iron bar bent into the form of a horse-shoe magnet, and furnished with a tripod stand, for the convenience of supporting the magnet and weight: if the small pot sustaining battery be connected in the usual manner with the ends of the coil, the soft bar of iron, as in the previous experiment, will immediately become a magnet capable of supporting upwards of thirty pounds weight. By this means temporary magnets may be obtained of an extraordinary power, in fact, there appears to be no limit to which they may not be extended; for, by employing adequate length of wire, and sufficient exciting surface, they may be constructed of almost any power; the author has one measuring 4½ inches in each leg, which with one of the small batteries will sustain a weight of 200lbs. Professor Henry, of America, has constructed one capable of sustaining the enormous weight of 4,640lbs.: thus requiring the average strength of two powerful horses to separate the feeder from the magnet.

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* The Electro-Magnetic Telegraph, lately invented, depends upon this property of the Electric fluid.

The Royal Gallery of Practical Science are in possession of one constructed by Mr. Marsh, of Woolwich, which will sustain upwards of 560lbs.

Exp. 11.—*Fig.* 14. This apparatus is intended to exhibit the magnetic polarity of a temporary, or electro-magnet. It is simply a bar of soft iron, having a coil of wire wound round it as before, the terminations of which dip into two circular cups of mercury, the latter being in connexion with the cups in the base of the instrument, when the battery connexion is made, magnetic properties are immediately established, in the iron, which from its having free motion immediately, arranges itself in the direction taken by the magnetic needle.

Exp. 12.—*Fig.* 24, is for shewing the rotation of an electro-magnet on its axis. It consists of a short bar of soft iron, covered with a helix of copper wire, the ends of which dip into the mercury trough, the latter being divided through the centre by a piece of ivory or cork, separating it into two troughs; in the base of the instrument is fixed an upright horse-shoe bar of soft iron, with the poles sufficiently apart to admit of the electro-magnet rotating between them: to exhibit the rotation, fill the two divisions of the trough with mercury; the latter should be very pure, or it soon becomes oxidized; at the same time taking care that they do not communicate by the mercury extending over the insulating partition; insert the poles of the battery into the holes on either side of the mercury trough, the electro-magnet will immediately commence rotating: it is to be observed, that when the battery connexion is made, the latter should be placed at right angles with the upright bars, or a slight impetus may be given after connexion is made.

The action of this instrument depends upon the temporary magnetism of the electro-magnet, the ends of which, (that is, the ends of the helical coil) connecting the two troughs of mercury, which may be considered as simply the poles of the battery, convey a current of Electricity through or around the wire, converting the soft iron into a powerful temporary magnet, a mutual attraction and repulsion then takes place between the latter and the iron bars, which are probably rendered slightly magnetic by induction from the influence of the electro-magnet; the latter being fixed, the former arranges itself so as to be in the same line with them, being the position it would take, supposing the horse-shoe bar was a permanent magnet; in doing this however it must quit the mercury troughs, and consequently all action ceases, but the momentum it has received is sufficient to carry it again into connexion with the battery: the current, in this case, by the alteration in the position of the coil of wire, flows in an opposite direction, giving the electro-magnet an opposite polarity to that which it possessed in its former position, that end of the bar which was North has now become South, when the same effects are renewed: these acting in rapid succession continue to keep up the rotation.

Several very interesting models have been constructed by different experimentalists, in which the rotation of one or more of these electro-magnets has been employed as motive powers for moving machinery; among these we may mention the contrivances of M. H. Jacobi, Messrs. Sturgeon, Lynn, and Mc Gauley, the apparatus, *figs*. 25 & 26, are the invention of Mr. Palmer, of Newgate Street.

Exp. 13.—*Fig*. 25, is the model of a saw mill, worked by electro-magnetism. The action of this apparatus is similar to that in the preceding experiments, for which the same directions will suffice; we have, however an addition to this, in the upright horse-sho of soft iron, which is also rendered magnetic by the action of a second battery, by this means the force of the rotations are greatly augmented; two batteries are therefore required in working this model, one being employed to magnetize the fixed horse-shoe bar, the other for the rotating magnet. The model continues to act as long as the batteries are in force.

Exp. 14.—*Fig.* 26, is the model of a pump set in motion by the same means; the principle is the same in both, this having a greater force to overcome; as the bucket of the pump, and the motion of the fly wheel, is furnished with four electro-magnets, both poles of which are made available by two sets of rotating magnets: in working this machine care must be taken that all the poles, either of the zinc or the copper-plates, are placed in the set of cups, coloured *red*, otherwise currents flowing in opposite directions are established, which would destroy the action.

Exp. 15.—*Fig.* 15, is intended to exhibit the rotation of an electro-magnet, by terrestrial magnetism. As the action of this instrument depends upon the earth's magnetism, care must be taken to arrange the division of the trough in the magnetic meridian, which is readily effected by observing the direction of a freely suspended magnetic needle; on the battery connexion being made, the electro-magnet will rotate, the polarity of the earth's magnetism supplying the place of the soft iron.

Several other interesting rotations have been invented by different experimentalists, which the limits of this work will not permit of being introduced, for the particulars of which we must refer the reader to works of greater magnitude and deeper research.*

Exp. 16.—Place each pole of the small battery, *fig.* 6, in a cup of mercury, and connect the two by a short wire, if the circuit be interrupted, by withdrawing one of the poles but a very faint spark will be seen.

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* Cumming's Electro-Dynamics, Ampère's Recueil d' Observations, Electro-dynamiques, Watkins Popular Sketch of Electro-Magnetism, and the Papers of Dr. Faraday in the Philosophical Transactions, Sturgeon's Annals of Electricity, &c., &c.

Exp. 17.—Screw into the holes *g*, *g*, *fig*. 27, two short wires to serve as conductors, (the apparatus is simply a long coil of wire wound round a wooden bobbin,) if contact be made, and broken with the battery, as in the previous experiment, a brilliant spark, accompanied by a snapping noise will be heard. This interesting fact of the increase of the spark by employing a long spiral conductor, was first discovered by Professor Henry, in the year 1832.

Exp. 18.—Screw into the apparatus *fig*. 27, the conductors *h*, *h*, as shewn in the diagram, grasp them firmly in the hands (having previously moistened them with water); and repeat the preceding experiment, while the conductors are retained in the hands; a shock will be felt each time contact is broken.

This fact was first noticed by Mr. Jenkins, who communicated the same to Dr. Faraday, and to whom we are indebted for several interesting and important facts connected with this phenomenon.

Exp. 19.—Repeat the same experiment: having previously inserted the iron bar, the shock will be much more severe than in the former experiment.

These experiments furnished Dr. Faraday and others with sufficient ground work for the discovery of some of the most interesting facts connected with the subjects of electro-magnetism and magneto-electricity.

Exp. 20.—Coil round a bar of soft iron about thirty or forty yards of thick copper wire, insulated by being covered with cotton, leaving a few inches at either end projecting; coil also upon the latter in the same direction another wire of the same length, leaving the ends projecting, which in this case must be at least a yard in length; connect these with the Galvanometer, *fig*. 21: if we now cause a current of Electricity to pass through the first wire by connecting the ends with the two poles of the small battery, there will also be produced another current in the second wire in an opposite direction to the battery current; which, at the moment of its exhibition, will deflect the needles of the Galvanometer. The action is but for a moment, however long the first current may be maintained: if we cut off the battery current from the first wire, there will also be another current set up in the second wire, but in this case it is in the same direction with the first or battery current.

These results were discovered by Dr. Faraday, and called by him the inducing and induced currents, from the supposition, that the latter were the result of induction, somewhat analogous to that produced by common Electricity.

Mr. Sturgeon, is opposed to the mode of reasoning, adopted by Dr. Faraday, and does not consider that these currents are indebted to that peculiar action of the electric fluid, called induction. He (Mr. Sturgeon) considers them to be the result of the exciting influence of the electro-magnetic lines, constantly flowing round an electrified wire, together with that of the polar-magnetic lines of the temporary magnet, but as the examination of this subject would lead us into a labyrinth of speculative theory, we must return to our more direct object, that of experimental investigation.

The apparatus we have now to describe, *fig*. 28. is one contrived by the author, and called by him the electro-magnetic-machine.* An account of which was read before the members of the Electrical Society in August last.

Its principal parts are, 1st. a compound helix, *i. e.* a wooden reel or bobbin, with a hole through the centre to admit of the insertion of an iron bar, &c. round which is coiled a thick copper wire, insulated by cotton, carrying the battery current; over which is coiled a thin insulated wire of the same metal of two thousand feet, the commencement and termination of each wire, being soldered to the binding screws attached to the bobbin. These coils for convenience we shall denominate, the priminary and secondary. 2ndly. of the contrivance for opening and shutting the battery current. We have two modes of effecting this; one consists of a spring and toothed wheel, the other that of a star wheel working between two fixed metallic cushions; in either case as the wheels rotate (by turning the multiplying wheel, at the back of the machine) they leave the springs, by which means the battery connexion is broken, and a vivid spark evolved.

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* This must not be confounded with the magneto-electrical machine, the action of which is very different, although the effects of the two very closely coincide.

During a course of experiments which the author was engaged upon with this instrument, he was led to the employment of a bundle of insulated iron wires, instead of the bar of solid iron generally employed, *See Exp.* 19, the insertion of which in the axis of the helix, he found gave an extraordinary increase in power; and which he is happy to find has been equally successful in the hands of other experimentalists. (It must, however, be observed, that no other form of iron can be successfully employed with them, if, as in some cases, it is made to surround the wires, it being self-evident, that they then with the outer tube form merely a solid bar, which the experiments of Messrs. Barlow and Sturgeon have proved to be less favourable for the developement of magnetic and electro-magnetic effects, than a hollow cylinder or tube; consequently no increase of power can be expected by their employment in such an arrangement;) attached to the frame-work of the machine are six binding-screws, *a, b, c, d, e, f,;* those on either side, *e, f,* are for securing the poles of the battery, *h,;* the two, *c, d,* on the top are for the reception of the conductors for giving the shock. *See Exp.* 21. Those on the two brass pillars are for effecting the calorific and electro-chemical effects.

To use this apparatus, screw the poles of the small sustaining battery *fig.* 6, into the holes *e,f,* by which means a current of Electricity is made to circulate through the primary or thick coil; the wheel being now put in motion, carries with it the toothed wheel: contact is rapidly made and broken, and a series of brilliant sparks are emitted, which from their rapid evolution, appear as one brilliant star.

Exp. 21.—Screw into the holes, *c, d.* the two conductors *figs.* 29. If the hands (being previously moistened) be now made to grasp the latter firmly, and the wheel at the same time put in motion, a rapid succession of shocks are experienced, producing the most excruciating agony, and such as few persons can withstand, even for a few seconds.*

Figs. 22, are two sponge directors for medical use: this instrument being admirably adapted for those cases, in which Galvanism has been found successful.

Exp. 23.—Screw into the hole, *a*, an iron wire, and into the opposite one of copper; to the other end of which a file must be securely fixed by twisting the wire round it several times: remove also the toothed wheel from its stand, then draw the end of the iron wire up and down the file, very beautiful scintillations will be thrown off, forming a very brilliant experiment if performed in a darkened room.

Exp. 24.—Remove the file from the copper wire in the last experiment, and press the latter (the connexion with the instrument remaining as in the former experiment) firmly on a sheet of tinned iron, that has been previously scratched with any pointed instrument; strew over the latter a few grains of bruised gunpowder; by drawing the iron wire briskly over the tin plate, in contact with the powder, it will be readily inflamed.

Exp. 25.—If a tea-spoonful of ether be substituted for the powder, the latter will, in like manner, be ignited.

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* In performing this Experiment, care should be taken not to continue the action of the machine after being requested to desist, as in most cases the muscles of the party receiving the shock are so forcibly contracted as to prevent them from loosening their hands from the conductors; the shock is, however much modified by removing the bundle of iron wires, *g, g*.

Exp. 26.—In the section on Voltaic Electricity, the decomposition of water was shewn by employing a series of the sustaining batteries, it being well understood that a single pair of plates is incapable of effecting it; by the aid of this instrument, the decomposition of water* is readily obtained by a single pair of plates of the smallest size. Dr. Wollaston's celebrated thimble battery, or even a wire of zinc and copper, being sufficient for the purpose.

Screw two copper wires into the holes, *a*, *b*, the ends of which must be made to dip into the cups of the apparatus, *figs*. 8 or 9; if the wheel be now revolved, the decompositions will proceed with some rapidity.

Exp. 27.—Substitute for the wires in the last experiment the platina plates *fig*. 31; place between these a piece of white blotting paper saturated with a solution of the iodide of potassium: after the wheel has been turned for a few seconds the salt will be decomposed. shewing, by the stain on the paper, the liberation of iodine. The neutral salts may be decomposed in a similar manner: litmus paper being employed instead of the former.

The apparatus is furnished with wheels and springs of several different metals, for shewing the variation in the light evolved; when these are employed, the effect is much increased by employing a more powerful battery.

Gold, silver, and copper, leaf, also readily undergo combustion when treated in a similar manner, displaying the characteristic light peculiar to each.

In conclusion, we may add, that all the effects of the compound or intensity battery, may be exhibited, by the ald of this instrument, with a single pair of plates.

FINIS.

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* In all these electro-chemical effects, the primary current is the one employed, the power of the secondary current, although capable of producing the most violent muscular action, possesses but very feeble decomposing or calorific properties.

A

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ORIGINAL COMMUNICATIONS.

ART. I.—CRITICISMS AND SUGGESTIONS RESPECTING NOMENCLATURE. By ROBERT HARE, M. D., Professor of Chemistry in the University of Pennsylvania.

ALSO, A LETTER FROM THE CELEBRATED J. J. BERZELIUS.

[*To the Editors of the Journal of Pharmacy.*]
PHILADELPHIA, *March 4th*, 1837.

Dear Sirs—In September, 1833, I published in your Journal, together with some encomiums upon the Treatise of Chemistry by the celebrated BERZELIUS, certain objections to his nomenclature, and some suggestions respecting a substitute, which I deemed to be preferable. In the following June I addressed a letter to Professor SILLIMAN upon the same topics, in which my criticisms and suggestions were amplified and corrected in obedience to more mature reflection. A printed copy of that letter having been sent by me to BERZELIUS, I received in answer an epistle, of which I furnish you with a translation.

Since the period of that correspondence, so demonstrative of candor and good feeling on the part of the great Swedish chemist, I have published two editions of my Compendium of Chemistry, in which I have pursued a course corresponding with my criticisms above alluded to. I am therefore desirous, in addition to the letter of BERZELIUS to lay before the public a recapitulation, review, and an additional explanation of the grounds upon which I have ventured to employ a language, and an arrangement inconsistent with the practice and opinions of a chemist by whose authority in other respects I am usually influenced. But before proceeding with the ungracious task of endeavouring to establish the correctness of my views in opposition to those of my friend, I feel that it will be no more than justice to repeat an acknowledgment, already made in my text book, that if De Bonsdorff, myself, and others are right in considering the *double* salts of Berzelius as *simple* salts, it is to the light afforded by his investigations, that we owe the power of seeing the subject correctly. I believe the idea, that any other body besides oxygen could produce both acids and bases capable of forming salts, originated with Berzelius, in the instance of sulphur.

Recapitulation and review of the grounds of his deviating from the language and arrangement of Berzelius, *and other distinguished chemists; with some additional explanations and suggestions, by* R. Hare, *M. D., Professor of Chemistry in the University of Pennsylvania.*

According to the Berzelian nomenclature, bodies which produce salts by a union with radicals are called *halogen* or *salt producing bodies*, while those which with radicals form both acids and bases, capable by their union of constituting salts, are called *amphigen bodies* or *both producers.* Salts, produced by the first mentioned class are called haloid salts; Those produced by the other are called amphide salts.

I objected to this classification, that the words *salt, acid* and *base*, were broad, vague and unsettled in their acceptation, having, by chemists in general, and especially by Berzelius, been employed to designate substances differing in composition, and extremely discordant in their properties; that no method of defining a salt had been devised, which had not been founded either on properties or composition; that in the nomenclature of Berzelius properties were disregarded, since among his haloid and amphide salts were found substances differing extremely in this respect. Thus, for instance, common salt, Glauber's salt, Epsom salt, vitriolated tartar, and cream of tartar, were associated with the fuming liquor of Libavius, the butyraceous chlorides of zinc, antimony, and bismuth, plumbum corneum, luna cornea, fluor spar, and the acid fluorides of silicon and boron. I objected also that composition could not be resorted to consistently with his classification; since, agreeably to it, a salt might be either a binary compound of a halogen body with a radical, or consist of two binary compounds, each containing the same amphigen body.

To the terms *acid* and *base*, as employed in his nomenclature, I objected, that neither by the celebrated author, nor by any other chemist had any definition been adhered to which could, consistently with his plan, restrict the meaning of those appellations to the binary compounds formed by the union of his amphigen bodies with radicals.

Acidity and basidity* had sometimes been distinguished by an appeal to properties, sometimes to composition, but to neither had there been any consistent attention. In order to demonstrate the total neglect of properties latterly displayed, it was only necessary to contrast substances bearing generally the name of acids; as for instance sulphuric acid with rock crystal, acetic acid with tannin, and prussic acid with margaric; or to contemplate simultaneously the admission of the hydracids formed with the halogen bodies into the class of acids, while alleged incapable of combining with bases, with the exclusion from that class of nitrous acid, upon the plea of the same incapacity.

In reference to neglect of composition in forming the class of acids, it will be sufficient to advert to the association in that class, of compounds formed with radicals both by the halogen and amphigen bodies; so that the halogen bodies are in one case producers of salts, in the other producers of acids; in one case act as supporters, acidifiers, or electro-negative principles, in another as radicals to the comparatively electro-positive hydrogen, pre-eminently a radical by the definition of that word given in the treatise of the distinguished author of the nomenclature.

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* For the use of the words basidity and salidity, I have no authority; but conceive that through their analogy with acidity their meaning is so obvious as to make it expedient to employ them.

After stating my objections to the basis of the **Berzelian** nomenclature, I proceeded to mention those to which I considered the superstructure as liable.

Having designated the acid compounds of his amphigen class, by prefixing syllables indicating their electro-negative ingredients; having also in some instances, as in those of the fluosilicic, and fluoboric acids, adopted this course in relation to halogen bodies; I objected to the use of the word hydracid, in which the electro-positive radical is made to act as if coordinate with oxygen.

Moreover, the termination in *ide* having been generally attached to the electro-positive compounds of oxygen, acting as bases, I condemned the employment of that termination, to distinguish the electro-negative, and acid compounds of sulphur, selenium, and tellurium. I considered it inconsistent to give precedence to the syllable designating the radical in the acids formed with hydrogen; as in hydrochloric, hydrobromic, hydriodic, hydrofluoric, hydrofluoboric, hydrofluosilicic, preferring the terms chlorohydric, bromohydric, iodohydric, fluohydroboric, fluohydrosilicic, &c., in which I have been sanctioned by **Thenard** and others.

I proposed a definition of an acid, and a base, which I conceived to be the only one which could be adopted, consistently with the use made of those words by **Berzelius**, and other distinguished chemists; and advanced that, agreeable to that definition, his double haloid salts must be considered as *simple* salts, severally formed of an acid and a base.

I objected to his treating the words combustion, and oxygenation as synonymous.

Having thus made the reader acquainted with the substance of my criticisms upon the **Berzelian** nomenclature, I will subjoin his letter in answer to them, and will then state, and endeavour to justify, the conclusions at which I have arrived.

Letter from J. J. BERZELIUS *of Stockholm to* R. HARE, M. D., *Professor of Chemistry in the University of Pennsylvania, acknowledging the receipt of a communication respecting Nomenclature, and replying thereto.*

STOCKHOLM, *September 23d,* 1834.

Sir—I am very much obliged to you for the remarks, which, under the date of June 21st, you had the friendship to communicate to me, respecting the nomenclature which I have employed in my Treatise of Chemistry.

I perceive that having contemplated chemical phenomena under different points of view, we differ as to the nomenclature which is the most appropriate for their description. I consider the combinations of metals with chlorine, bromine, &c., as salts; whilst you, in accordance with Mr. DE BONDSDORFF, consider them as bases and acids, capable of forming salts by their union.

If it were expedient that chemical classification should be dependent on the number of simple bodies which enter into each combination, this idea of Mr. DE BONDSDORFF would without doubt be preferable; but if attention be due to the chemical properties which characterize combinations, we cannot adhere to an arrangement founded on the number of the elements. Yet so essential is it in chemistry to have reference to properties, that a system of chemistry in which common and analogous properties should not affect the arrangement, would present a mass of facts so chaotic, that no memory would be competent to retain them. In a system thus strictly conformable to the ideas of Mr. DE BONDSDORFF, cyanogen, though in its properties resembling chlorine or bromine which are simple bodies, ought to be considered, also, as a base or as an acid having azote for its radical—I am persuaded you would not approve of extending the system of DE BONDSDORFF so far; but if it be correct, it would be inconsistent not to make this extension.

But let us return to the combinations of the metals with chlorine, fluorine, &c., and make, in imagination, the following experiment. Let us take two portions of caustic potash, a base in which the *basic* characters are more striking than in any other. To one, let us add a sufficiency of sulphuric acid to extinguish entirely its *basic* property; we shall then have a neutral body of a saline taste. You will admit it to be a salt. Now let us add to the other portion, hydrofluoric acid. At a certain point the *basic* properties of the potash will disappear, and we shall have a resulting compound quite as neutral as the sulphate of potash, endowed with a saline taste entirely analogous to that of the sulphate. The basic properties of the potash are destroyed by the hydrofluoric acid, as well as by the sulphuric acid. But you will allege the resulting combination is not a salt, but a base which has exchanged one basifier (oxygen) for another basifier (fluorine.) In proof you may add as much more hydrofluoric acid, which combining with the new base will form with it a crystallized salt. But this salt is not neutral, it has almost the same acidity of taste as the hydrofluoric acid employed. The new base does not destroy then the acid reaction.

Let us make a further addition of sulphuric acid to the sulphate of potash. A salt equally acid will result, in which the sulphate of potash acts the same basic part towards the sulphuric acid, as the fluoride of potassium towards the hydrofluoric acid. Should it be desired to extend the comparison further, it will be found that for each less electro-positive fluoride, susceptible of combination with the potassic fluoride, there will be, with but very few exceptions, a corresponding sulphate, susceptible of combination with the sulphate of potash. The analogy is then complete, it exists not only in the perfect neutrality of the two potassic salts, in their saline taste, but also in their manner of forming combinations with other bodies; notwithstanding one of them, the sulphate, contains one element more than the other. If, instead of potash, potassium were employed to saturate our two acids, the analogy of the operation in both cases, would be still more complete. The same quantity of metal, would displace equal volumes of hydrogen. When the visible results of our experiments are so perfectly analogous, it is to be presumed that the invisible process which we do not see, may also be perfectly analogous, and that if facts exactly alike are explained differently, there must be a defect in the explanation. If, for instance, the true electro-chemical composition of the sulphate of potash should not be $KO+SO^3$, as is generally supposed, but $K+SO^4$,[*] and it appears very natural that atoms, so eminently electro-negative as sulphur and oxygen, should be associated, we have, in the salt in question, potassium combined with a compound body, which, like cyanogen in $K+C^2N$,[†] imitates simple halogen bodies, and gives a salt with potassium and other metals. The hydrated oxacids, agreeably to this view, would be then hydracids of a compound halogen body, from which metals may displace hydrogen, as in the hydracids of simple halogen bodies. Thus we know that SO^3, that is to say, anhydrous sulphuric acid, is a body whose properties, as respects acidity, differ from those which we should expect in the active principle of hydrous sulphuric acid.

The difference between the oxisalts, and the halosalts is very easily illustrated by formulæ. In K|FF—fluoride of potassium, there is but one single line of substitution, that is to say, that of K|FF, whilst in KOOOOS (sulphate of potash) there are two, K|OOOOS and KO|OOOS of which we use the first in replacing one metal by another, for instance, copper by iron; and the second in replacing one oxide by another.

I do not know what value you may attach to this developement of the constitution of the oxysalts (which applies equally to the sulphosalts and others): but as to myself, I have a thorough conviction, that there is therein, something more than a vague speculation; since it unfolds to us an internal analogy in phenomena, which, agreeably to the perception of our senses, are externally analogous. If these phenomena are to be considered agreeably to the ideas of Mr. DE BONDSDORFF, how does it happen that sulphur, phosphorus, arsenic, and other radicals of the strongest oxacids, when united with chlorine, bromine, iodine, &c., do not combine with the chlorides,* bromides, &c., of the metals of the alkalies and of the earths; whilst the chloride and bromide of potassium combine easily with those of magnesium, iron, and manganese. Should then the chloride of magnesium, or that of manganese, be a stronger acid than the chloride of sulphur, or chloride of phosphorus? How is it consistent with these ideas that we can obtain crystallized salts as well with, as without water, of combination, composed of chloride of calcium and of oxalate, or of acetate of lime? Should the oxysalt be here the acid, or the base? I have now displayed to you, the considerations which have guided me, and which I think are not destitute of foundation.

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[*] In the Berzelian symbols, K stands for kalium, or potassium, S for sulphur, O for oxygen, and O^3 for three atoms of oxygen, O^4 for four atoms of oxygen.

[†] That is to say, if the salt called sulphate of potash, be considered as compound of potassium, and a quadroxide of sulphur, instead of being viewed as a protoxide of potassium, or potash, and tritoxide of sulphur, or sulphuric acid.

This is the formula for cyanide of potassium, consisting of potassium, K, and cyanogen, or two atoms carbon and one of nitrogen, C^2N.

I cheerfully admit that it would be preferable to employ the word chlorohydric, instead of hydrochloric. My motive for retaining this last, is, that I have ventured to propose a new nomenclature in a language foreign to me, in which it was inexpedient to make changes which could be avoided without inconvenience. I also agree with you, that we ought not to use combustible and oxidable, as having the same meaning. I have deserved your strictures for this inconsistency in my language; but I must suggest as an apology, that the two words were formerly used as synonymous, and that the work, in which you have recently noticed this oversight, was first published in 1806, having been from time to time remoulded for new editions, without its having been possible to eradicate all that has not kept pace with the progress of science.

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* I have translated chlorure, fluorure, bromure, by chloride, fluoride, and bromide, agreeably to the practice of the British chemists.

Accept the assurance of my perfect esteem, and of the sentiments of sincere friendship with which I have the honour to be,

Yours, &c.

An Examination, by the Author of this Article, of the Suggestions in the preceding Letter of BERZELIUS, *and how far the Objections made to his Nomenclature, are therein answered.*

So far as my strictures were founded on the alleged difficulty of defining the terms acid, salt, and base, in any mode consistent with his classification, they are not met by any facts or reasoning in the much esteemed letter of my illustrious correspondent. The impracticability of defining a salt, he does not deny; and with great candour he admits that, in his definition of acidity, he has not been consistent. He concedes that it would be preferable to give the syllable, indicating the electro-negative ingredient, the precedence, as nothing but unwillingness to innovate, prevented him from pursuing that course.

He acknowledges that as combustion, in many instances, takes place without the presence of oxygen, the application of the word combustible, should not be confined to bodies which are susceptible of oxydizement.

My definition of acidity was as follows:—

"*When, of two substances capable of combining with each other so as to form a tertium quid,* and having an ingredient common to them both, one prefers the positive, the other the negative pole of the Voltaic series, we must deem the former an acid, and the latter a base. Also all substances having a sour taste, or which redden litmus,*

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* This term *tertium quid* has been used by chemists, more formerly than of late, to designate a compound resulting from the union of two bodies, but in its properties resembling neither.

must be deemed acids, agreeably to usage." This definition I would now amend by leaving out the last sentence, and substituting therefor, the following: *Also when any substance is capable of forming a tertium quid with any acid or base agreeably to the preceding definition, it must be considered as an acid in the one case, a base in the other.* The definition, thus amended, takes in the organic acids and bases. In the form in which it was at first proposed, it has not been alleged defective by BERZELIUS; but he has striven to show an incongruity in the attributes of his double salts, when contrasted with those resulting from the union of some of the acids and bases of his amphigen class; which incongruity is, in his opinion, a sufficient reason for not considering them as *simple* salts, and their ingredients as acids and bases, agreeably to the opinions of DE BONSDORFF and myself.

BERZELIUS errs in confounding my opinions with those of DE BONSDORFF. However I may have admired the sagacity with which that chemist investigated the pretensions of some haloid salts to certain attributes of acidity or alkalinity; in my letter on the BERZELIAN nomenclature, I signified my unwillingness to rest my opinions upon a basis so narrow, as that which he had endeavoured to establish. I stated that I did not deem it necessary to appeal to his excellent observations, proving certain attributes of acidity to exist in one case, those of alkalinity in the other. I alleged my definition to be founded on the conviction that the property of affecting vegetable colours, on which that sagacious chemist lays so much stress, has not, latterly, been deemed necessary in acids; and that in bases it never was required. As respects them, it only served as a mean of subdivision between alkaline oxides and other oxibases.

I am at a loss to discover in what part of my letter there was any language which could convey the erroneous impression, that, in defining acids and bases I proposed to overlook properties, and to be regulated by attention to the number of atoms in a compound. Certainly nothing was more foreign to my thoughts.

It is assumed by Berzelius that the saturation of the fluobase of potassium by fluohydric acid, cannot be considered as analogous to the saturation of the oxybase of potassium by sulphuric acid; because the resulting compound is to the taste in one case neutral, in the other sour. In reply I suggested that if the salidity of the biborates and bicarbonates was not to be questioned on account of their alkaline taste, nor that of the protochloride of tin on account of its sourness, it was not consistent that the pretensions to salidity of the fluohydrate of the fluobase of potassium should be denied on account of its sour taste. I will now add that if the fluosilicate of potassium be a double salt, the fluoride of silicon one of its two constituents must be a simple salt, and yet it is sour. If a simple salt may be sour, why may not a double salt have this attribute; and how in fact can its presence be inconsistent with salidity? Is not the absence of this characteristic in silica and tannin, and many other acids, as much against their claims to acidity, as its presence in other compounds is an objection to their association with saline bodies. It is considered by Berzelius an objection to the views which I have espoused, that the halogen bodies, while forming acids with various metallic radicals which oxygen does not acidify, do not form acids with sulphur, phosphorus, and arsenic which oxygen does acidify; yet what is there in this, more difficult to reconcile with the established results of chemical combinations, than in the fact that oxygen forms with sulphur, phosphorus, and arsenic, strong acids, with hydrogen water; while with hydrogen the halogen bodies all form compounds which Berzelius describes as having the highest pretensions to acidity. The highly active acid properties of the fluorides of boron and silicon, would lead us to expect similar compounds to be formed by the same radicals, with the other halogen bodies, contrary to experience. Chemistry makes us acquainted with many similar discordances. How is it that oxygen forms aëriform compounds with an extremely fixed body in the instance carbon; while in that of phosphorus or arsenic, both volatilizable, it forms acids which are comparatively insusceptible of volatilization? Wherefore does not hydrogen produce an acid with phosphorus and arsenic, as well as with sulphur?

According to **Berzelius**, all the halogen bodies produce with hydrogen combinations which are as highly endowed with the attributes of acidity, as the strongest acids into which oxygen enters as a constituent. It is conceded in his letter that his language respecting these combinations cannot be reconciled with his declaration in one place that they do not combine with oxybases, and in another that a body which cannot so combine is not an acid. It strikes me, that the only way in which the admitted inconsistency of his description of these bodies, with his definition of acidity, can be avoided, is by assuming that they combine as acids with haloid bases, although decomposed by oxybases.

I will now proceed to comment on a new subject for consideration, presented in **Berzelius**'s letter in reply to mine.

It must be evident that every oxysalt, composed of an oxacid and an oxybase, must consist of an atom of each radical, and as many atoms of oxygen as exist both in the acid and in the base. Thus sulphate of potash consists of an atom of potassium, an atom of sulphur and four atoms of oxygen, and may be represented either by SOOO KO or SOOOOK.

Berzelius in his letter repeats an ingenious suggestion previously advanced in his treatise, that SOOOO, (sulphur with four atoms of oxygen,) may act, as a compound halogen body like cyanogen, and thus form a salt by union with an atom of any radical. He conceives that the apparent want of analogy, which induced him to separate into two classes, the amphigen and halogen bodies, disappears under this view of the phenomena; and that his amphide salts might be considered as constituted of a compound halogen body and an elementary radical. But however we may admire the ingenuity of these suggestions, ere, in obedience to them, we extend the limits of the halogen class, I would request that the word salt should be defined, and that it be shown that consistently with any definition which can be devised, there is any class of bodies in nature which merit the appellation of salt-producers. Before enlarging the superstructure, let it be shown that the basement has been well grounded.

Berzelius lays some stress on the community of effect, in the evolution of hydrogen, both by acids formed by hydrogen with halogen bodies, and by diluted hydrous sulphuric acid, as evincing a similitude of composition justifying the suggestion above quoted from him. But I conceive that this common result is better explained by ascribing it to the tendency of radicals to displace each other from combination, whether existing in a simple or a complicated compound. If water exists as a base in hydrous sulphuric acid; as I have elsewhere suggested, we may consider this hydrous acid as a sulphate of the oxybase of hydrogen; and that when it reacts with zinc or iron, the proneness of hydrogen to the aëriform state enables either metal to take its place, agreeably to the established laws of affinity.

It may be proper, before concluding, to explain more particularly the nomenclature which I have adopted.

The amphigen, and halogen bodies of Berzelius, as they produce acids and bases according to my definition, are all classed as basacigen bodies. Of course oxygen, chlorine, bromine, iodine, fluorine, cyanogen, sulphur, selenium, and tellurium, are included in this class.

The general designation of a binary compound of a basacigen body, is the termination in *ide;* the special, the termination in *acid*, when the compound acts as an acid, in *base*, when it acts as a base.

Hence an oxide, may be an oxacid, or an oxybase;

a chloride,	a chloracid,	or a chloribase;
a bromide,	a bromacid,	or a bromibase;
an iodide,	an iodacid,	or an iodobase;
a cyanide,	a cyanacid,	or a cyanobase;
a sulphide,	a sulphacid,	or a sulphobase;
a selenide,	a selenacid,	or a selenibase;
a telluride,	a telluracid,	or a telluribase;

Compounds which consist of radicals only, are distinguished by the term *uret* equivalent to the French *ure*. Hence *carburet*, *phosphuret*, *boruret*, *silicuret*, *&c.*

Of any two binary compounds containing each the same basacigen body and forming one compound, the more electronegative is an acid, the other a base. Hence all the electronegative haloid compounds in the BERZELIAN double salts, are acids, and the electro-positive, bases. Where there are two such compounds one containing one basacigen atom, the other two atoms or one and a half, the former has a termination in *ous*, the latter in *ic*. As for instance the *chlorureplatinoso-potassique* of BERZELIUS, is a compound of *chloro platinous acid*, and the *chlorobase of potassium*, and is the *chloroplatinite of potassium*. The *chlorureplatinico-potassique* of the same author, is the *chloroplatinate of potassium*.*

By analogy the intelligent reader may easily make these examples a clue to designate any other of the double salts of BERZELIUS so as to accord with the plan in question. He may have a *bromoplatinate* or *bromoplatinite*, a *iodoplatinate* or *iodoplatinite*, a *fluoplatinate*, *&c.*; or changing the radical a *chloroaurate* or *chloroaurite*, a *bromoaurate* or *bromoaurite &c.*

The terms amphigen and halogen being employed both from expediency, and in honour of their author, we may use his terms haloid and amphide, to distinguish the acids or bases severally formed by these classes, the abbreviations *halo* and *amph*, being employed in composition. Thus I designate the acids formed by the halogen bodies with hydrogen, as halohydric acids; those formed with that radical by the amphigen bodies, as amphydric acids. As the same radical will in other cases be found to form acids with several of the halogen bodies, platinum for instance, the acids thus produced, may be called haloplatinic acids ; or if gold were the radical, they would be called haloauric acids. These examples will suggest to the chemical reader a series of names, as for instance *haloargentic*, *halocupric*, *halostannic*, *halopalladic*.

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* In designating salts of the metals proper, as for instance, the *nitrate of mercury;* the idea of the oxydisement of the metal is always understood, although usually not expressed. In the instance above cited, we actually mean the *nitrate* of the *oxide*, or *oxybase* of mercury. By analogy, I here use the term *chloroplatinate of potassium*, for *chloroplatinate* of the *chlorobase* of *potassium*. It is in fact, well known to Chemists, that acids do not unite directly with metals. The only alleged exception to this rule, of which I have any knowledge, is that of tellurium and sulphuric acid. It is inferred, therefore, that when an acid is combined with a metal, the latter must exist in the state of a base formed with the basacigen body which enters into the composition of the acid.

I consider prussian blue as a cyanoferrite of the cyanobase of iron, or briefly a cyanoferrite of iron. The diversity of properties which enables two cyanides of iron to exist in combination in this cyanoferrite, one as an acid, the other as a base, is one among many other instances in which compounds constituted of the same elements in the same ratio, have different properties, and are said in consequence to be *isomeric*, or to afford cases of *isomerism*.

The salt designated by Berzelius as the "*cyanure ferroso-potassique*," is the well known test for iron heretofore called ferroprussiate of potassa ; under the idea that it consisted of prussic acid, iron, and potassa. As the prussic acid was viewed at the same time as a compound of hydrogen and cyanogen, the ferroprussic acid was considered as a compound of cyanogen, hydrogen, and iron. According to Berzelius, the supposed *ferroprussiate* is a compound of a "*protocyanure*" of iron, and a "*cyanure* of *potassium* ;" each being a simple haloid salt, and the aggregate a double "*cyanure*." Agreeably to my nomenclature, the "*protocyanure*" of iron is considered as cyanoferrous acid, and the "*cyanure*" of potassium as a cyanobase; the aggregate being a cyanoferrite of the cyanobase of potassium, but designated briefly as a cyanoferrite of potassium.

I infer that the "*ferroprussic*" acid is analogous in constitution to the triple compound of fluorine, silicon and hydrogen, improperly called hydrofluosilicic acid ; and that, consistently with the hypothetical views under which the latter received its name, the former should be called hydrocyanoferric acid. Even admitting the correctness of the hypothetical impression, to which I have alluded, agreeably to which such compounds are acids with a double radical, I urged that the appellations of such compounds should be so altered as to give precedency to the electro-negative ingredient. Hence the one would be called cyanohydroferric acid; and the other, fluohydrosilicic acid. But in my letter to SILLIMAN, already cited, I advanced a new hypothesis respecting the constitution of the fluohydrosilicic, and fluohydroboric acids. I suggested that they should be considered as compounds in which the fluorides of silicon or boron acted as acids, the fluoride of hydrogen as a base. Consistently with that doctrine, I would consider the *protocyanide* (or "*cyanure*") of iron in the alleged *ferroprussic acid,* as acting as *cyanoferrous acid,* the *cyanide* of *hydrogen* (*prussic acid*) as a *cyanobase* forming, by their union, a cyanoferrite of hydrogen.

As compounds, consisting of a basacigen body, hydrogen and a radical, do not, when presented to bases, enter into combination; but are, on the contrary, decomposed so as to allow another radical to take place of their hydrogen, it is inconsistent with chemical law, as stated by BERZELIUS,* or my definition of acidity, (page 9,) to designate them as acids.

I have called the electro-negative "*protocyanure*" of iron of BERZELIUS, cyanofer*rous* acid, because there is "sesquicyanure" in the *cyanureferrico-potassique*" of that author, which, by analogy with the nomenclature of the oxacids, is entitled to the appellation of cyanoferric acid.

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* Traite, page 41, vol. ii.

From the American Journal of Science and Arts, No. 2. Vol. 35.

Notice from Dr. Robert Hare, Professor of Chemistry, &c., *respecting the fusion of platina, also respecting a new Ether, and a series of gaseous compounds formed with the elements of water.*

TO PROF. SILLIMAN.

Philadelphia, Dec. 15th, 1838.

My Dear Friend,—I send you for the Journal a brief notice of some results, observations, and inferences, which are nearly in the same language in which they were communicated to the Chemical Section of the British Association for the Advancement of Science.

I have by improvements in my process for fusing platina, succeeded in reducing twenty five ounces* of that metal to a state so liquid, that the containing cavity not being sufficiently capacious, about two ounces overflowed it, leaving a mass of twenty three ounces. I repeat that I see no difficulty in extending the power of my apparatus to the fusion of much larger masses.

When nitric acid or sulphuric acid with a nitrate is employed to generate ether, there must be an excess of two atoms of oxygen for each atom of the hyponitrous acid which enters into combination. This excess involves not only the consumption of a large proportion of alcohol, but also gives rise to several acids and to some volatile and acrid liquids.

It occurred to me that for the production of pure hyponitrous ether a hyponitrite should be used. The result has fully realized my expectations.

By subjecting of hyponitrite potassa or soda to alcohol and diluted sulphuric acid, I have obtained a species of ether which differs from that usually known as nitrous or nitric ether in being sweeter to the taste, more bland to the smell, and more volatile. It boils below 65° of F., and produces by its spontaneous evaporation a temperature of 0 – 15° F. On contact with the finger or tongue it hisses as water does with red hot iron. After being made to boil, if allowed to stand for some time at a temperature below its boiling point, ebullition may be renewed in it apparently at a temperature lower than that at which it had ceased. Possibly this apparent ebullition arises from the partial resolution of the liquid into an aeriform ethereal fluid, which escapes, both during the distillation of the liquid ether and after it has ceased, at a temperature below freezing. This aeriform product has been found partially condensible by pressure, into a yellow liquid, the vapor of which, when allowed to enter the mouth or nose, produced an impression like that of the liquid ether. I conjecture that it consists of nitric oxide, so united to a portion of the ether as to prevent the wonted reaction of this gas with atmospheric oxygen. Hence it does not produce red fumes on being mingled with air.

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* Troy weight. The actual quantity fused was 12,250 grs.; the lump remaining weighed 10,937 grs.

Towards the end of the ordinary process for the evolution of the sweet spirits of nitre, a volatile acrid liquid is created which affects the eyes and nose like mustard, or horse radish.

When the new ether as it first condenses is distilled from quicklime, this earth becomes imbued with an essential oil which it yields to hydric ether. This oil may be afterwards isolated by the spontaneous evaporation of its solvent. It has a mixed odor, partly agreeable, partly unpleasant. From the affinity of its odor and that of common nitrous ether, I infer that it is one of the impurities which exist in that compound.

The new ether is obtained in the highest degree of purity, though in less quantity, by introducing the materials into a strong well ground stoppered bottle, refrigerated by snow and salt. After some time the ether will form a supernatant stratum, which may be separated by decomposition. Any acid, having a stronger affinity for the alkaline base than the hyponitrous acid, will answer to generate this ether. Acetic acid not only extricates but appears to combine with it, forming apparently a hyponitro-acetic ether.

I observed some years ago that when olefiant gas is inflamed with an inadequate supply of oxygen, carbon is deposited, while the resulting gas occupies double the space of the mixture before explosion. Of this I conceive I have discovered the explanation. By a great number of experiments, performed with the aid of my barometer gauge Eudiometer, I have ascertained that if during the explosion of the gaseous elements of water any gaseous or volatile inflammable matter be present, instead of condensing there will be a permanent gas formed by the union of the nascent water with the inflammable matter. Thus two volumes of oxygen, with four of hydrogen, and one of olefiant gas, give six volumes of permanent gas, which burns and smells like light carburetted hydrogen. The same quantity of the pure hydrogen and oxygen with half a volume of hydric ether gives on the average the same residue. One volume of the new hyponitrous ether under like circumstances produced five volumes of gas.

An analogous product is obtained when the same aqueous elements are inflamed in the presence of an essential oil. With oil of turpentine a gas was obtained weighing per hundred cubic inches $16\frac{5}{10}$ grs., which is nearly the gravity of light carburetted hydrogen. The gas obtained from olefiant gas, or from ether, weighed on the average, per the same bulk $13\frac{5}{10}$ grs. The olefiant gas which I used weighed per hundred cubic inches only $30\frac{5}{10}$ grs. Of course if per se expanded into six volumes it could have weighed only one sixth of that weight, or little over five grains per hundred cubic inches. There can therefore be no doubt that the gas obtained by the means in question, is chiefly constituted of water, or of its elements in the same proportion H^2O.

With a volume of the new ether, six volumes of the mixture of hydrogen and oxygen give on the average about five residual volumes. The gas created in either of the modes above mentioned does not contain carbonic acid, and when generated from olefiant gas appears by analysis to yield the same quantity of carbon and hydrogen as that gas affords before expansion.

These facts point out a source of error in experiments, for analyzing gaseous mixtures by ignition with oxygen or hydrogen, in which the consequent condensation is appealed to as a basis for an estimate. It appears that the resulting water may form new products with certain volatilizable substances which may be present.

From the account of the proceedings of the Section, published in the Atheneum, it appears, that after my letter, in which the facts above mentioned were stated, was read, a Mr. Maugham, who is employed to exhibit the hydro-oxygen microscope at the Adelaide Gallery, London, asserted that I had accomplished the fusion, of which mention has been above made, by means of a blowpipe of his contrivance, which I had purchased while in London.

The opinion which I am obliged to entertain of an individual capable of this groundless assertion, would cause me to consider him unworthy of notice, had not his misstatement been made before an assemblage which I most highly esteem, and had he not been honored by a premium for his pretended invention by a respectable British Society.

The blowpipe which is thus falsely alleged to have been used by me, differs immaterially from one of which I published an engraving and description in the American Journal of Science for

1820, vol. II, p. 298, being a modification of that originally contrived by me and republished in Tilloch's Philosophical Magazine, vol. XIV, for 1802.

Between the instruments described in these publications, or in the Franklin Journal, and that employed by Maugham, the only difference worthy of notice is, that the latter is near the apex bent so as to form an acute angle, and is thus rendered suitable for directing the flame upon a revolving cylinder of lime.

Although I purchased of Newman a blowpipe bent as described, with an apparatus attached for holding and turning a cylinder of lime, *I have never made any use of it*, having for the purpose of subjecting lime to the flame, found my modification above referred to as described in this Journal, preferable. It only required the jet pipe to be directed upwards in an angle of about forty five degrees with the axis of the lime cylinder.

I do not consider the form of my blowpipe employed by Mr. M. as qualified for the fusion of any metal.

It is remarkable that an apparatus of gasometers employed by Maugham at the Adelaide Gallery for the supply of the gases for the blowpipe differs but little from the apparatus proposed for the same purpose in my communication above adverted to, and published nearly twenty years ago.

However the process by which I have lately extended the power of the hydro-oxogen blowpipe may differ from those to which I had previously resorted, it differs still more from that modification which Maugham has claimed as his own.

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